Polymer- LC based electrically switchable diffractive and emissive devices

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Electrically switchable and tunable holographic optical components based on composites of polymer-liquid crystal (H-PDLC) are of strong interest in optical communications, fiber optics, integrated optics, LC displays, for optical information processing and other electro-optical applications. However, typical H-PDLC or nano-H-PDLC exhibit strong light-scattering because of the presence of LC-droplets and high electrical switching fields.

Formation procedure and resulting optical and electro-optical properties of a new type of electrically switchable/tunable diffractive elements based on homogenous mixturees photo-curable monomers/liquid crystals are presented. The combination of the new composite materials with the holographic patterning results in volume phase gratings with high diffraction efficiency, high optical quality and excellent electro-optical parameters.

Diffractive structures consisting of alternating polymeric stripes and layers of planar aligned liquid crystals are formed due to photopolymerization and phase separation of the monomer components due to holographic exposure. The photo-induced phase separation forming LC areas and stripes of polymer network with respect to dark and bright regions of the interference pattern and the LC alignment along the grating vector form a film morphology characterized by periodic modulation of the refractive index through the film. The orientation of LC can be changed applying an electric field.

It will be shown that the realization of a line-type non-droplets grating morphology is provided by a precise control of the material formulation and the holographic irradiation intensity. The last one provides the optimal rate of photopolymerization and diffusion of the components, which results in an almost complete separation of the LC from the polymer. The subsequent nematic ordering of the LCs in the LC-areas enhances the refractive index modulation and the anisotropy of the grating due to the planar alignment of the LCs. It is an advantage of the developed system that all processing steps can be carried out all-optically at room temperature.

The kinetics of the holographic recording of the gratings under different recording intensities has been investigated. The microstructure of transmission gratings of different periods was investigated by optical polarization microscopy and AFM indicating line-type morphology of the gratings and a strong ordering of the LCs within the LC-areas. Electrical control of the director orientation in the LC-lines results in a switching or tuning of the grating diffraction efficiency. It Transmission volume structures with spatial periods of 300-6000 nm were realized.

The structures are characterized by high diffraction efficiency (up 99%) in the vis range and reasonable diffraction efficiency in the IR spectral range, negligible light-scattering because of the absent of LC-droplets, strong polarization dependence of the diffraction efficiency, low driving voltages (up to 2V/µm), fast time-response (up to 100 µsec) and large difference of the grating diffraction efficiency in ON- and OFF-state.